DIE CASTING ENGINEER

PUBLICATION OF THE SOCIETY OF DIE CASTING ENGINEERS / JULY 1961

alloys for die casting

DEVELOPMENTS IN THE PRESSURE DIE CASTING OF STEEL

- Page Seven
- Page Seventeen

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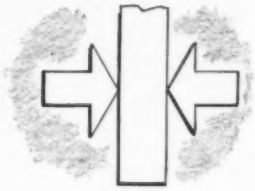

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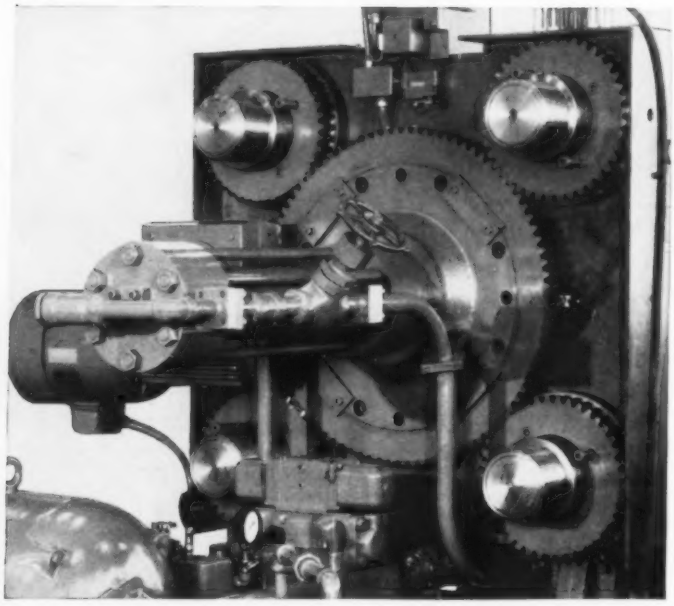

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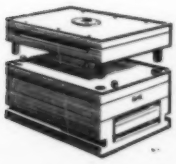

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John L. MacLaren

PRESIDENT'S REPORT

AN INFORMAL and admittedly rather casual survey of the U.S. die casting industry has revealed that the custom shops which have achieved status as quality suppliers over the years have not been too badly hurt by the recent recession in business activity. Their well-capitalized positions have enabled them to use this slack period to overhaul equipment, improve plant layout and generally make themselves more competitive. These shops expect better conditions ahead, with an increase in volume and profit very likely.

On the other hand, many of the small, recently-established, under-capitalized shops have had tough sledding in the past 18 months with sales volume often dropping well below 50 per cent of capacity. Due to their relatively insecure financial position, such companies may not be able to enjoy the fruits of expanding business conditions but may, instead, have to settle for the less-profitable jobs which the more secure shops prefer not to book into their plants.

Thus the next six months should see further readjustment in the die casting industry, with more of the tiny shops going out of business and the well-managed operations becoming even stronger.

There is a decidedly noticeable trend among the progressive jobbing die casting companies towards diversification and integration. Some are broadening out from zinc into aluminum and magnesium; others are entering the plastics field by installing equipment which utilizes the newest and most competitive plastic molding materials and processes; at least one forward thinking jobber has entered the aluminum extrusion business; and many die casters are exploring or have already adopted such competing processes as low pressure permanent molding of aluminum. In several instances, jobbing die casters have integrated forward by either marketing a consumer product themselves, or by buying out one or more of their customers for castings. With profit margins on die casting production squeezed as low as they are at present, the enterprising operator is energetically seeking ways of broadening out into more profitable lines, but at the same time utilizing the skills he has built up in his plant over recent years.

Captive die casters also foresee increased activity ahead. The automobile and appliance industries in particular have been in the doldrums, but both plan a variety of new models, all of which will mean increased consumption of die castings of all kinds. In the automobile business, there are a number of parts being scheduled as die castings which hitherto had been made in non-die castable materials by different processes. These changes have not come about spontaneously, but rather by diligent effort on the part of many people aware of the economic advantages of die casting.

June 30 concluded the fiscal year of the Society of Die Casting Engineers. The Society had a highly satis-

(Continued on Page 32)

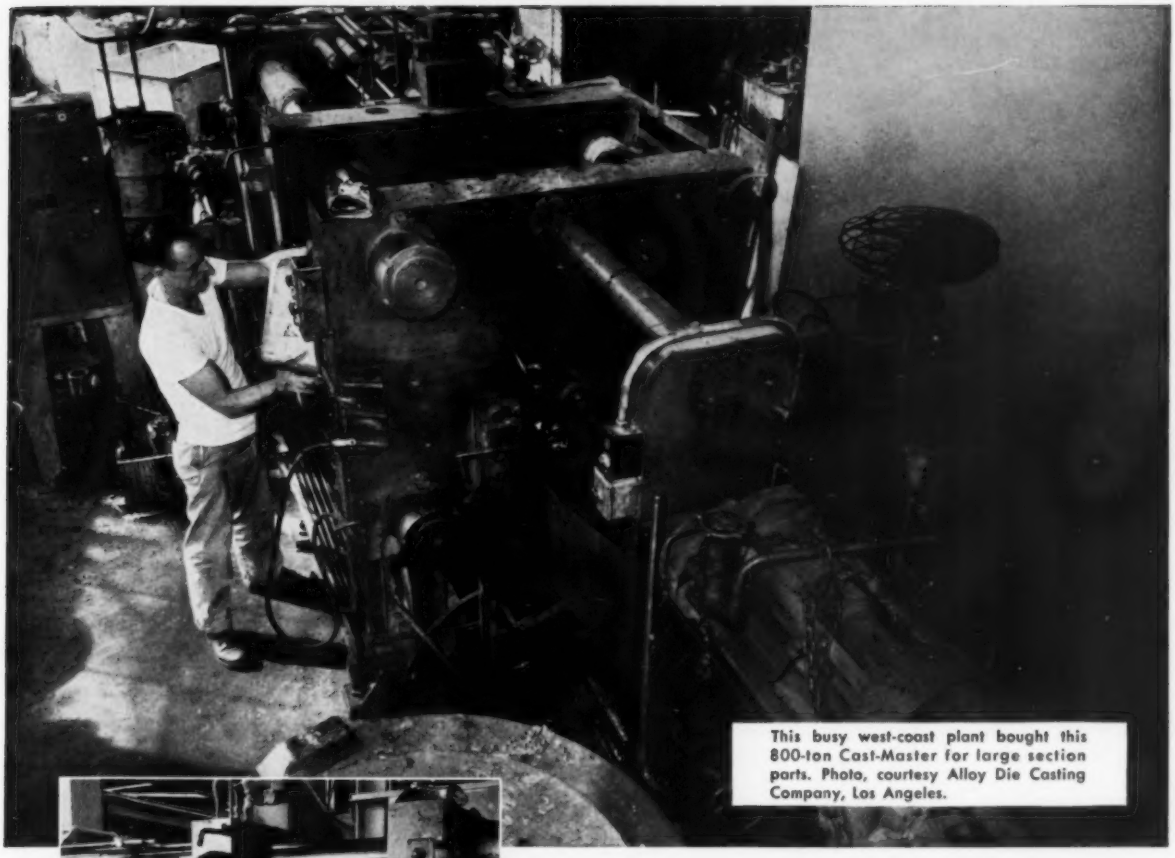
CODE OF ETHICS

As a result of comments registered recently by several prominent die casters regarding unethical practices of men connected with the industry, the Society of Die Casting Engineers has under consideration the drawing up of a code of ethics which would be applicable to both suppliers and die casters. To permit development of better relations between people and firms, the areas of our industry to which the code would apply might be these: The practice of carrying information regarding products or processes from one die caster to another; the pirating of personnel by one company from another; other undesirable and injurious practices which have an unhealthy effect on the advancement of the die casting industry.

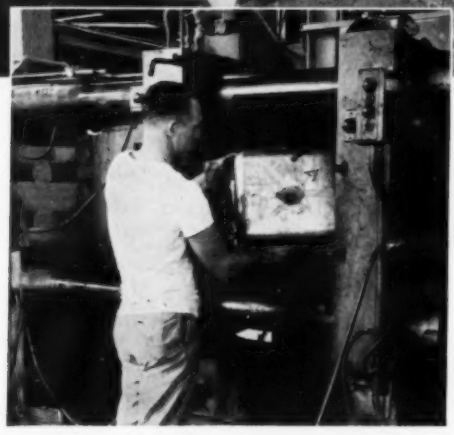
It is not the intention of the Society to set itself up as judge and jury, but merely to present a set of rules or code which may serve as guidance for those doing business or associated with the die casting industry. Such a code would not be binding in any manner, but rather would be a guide to the improvement of the industry in which the Society has a vital interest and is pledged to make a continuing contribution.

We invite constructive comment from our readers as well as suggestions concerning areas to be covered in the code. Please address all replies to the Society's National offices. If there is sufficient interest, a committee will be appointed by President John MacLaren to draw up and present such a code as another service of the Society to the industry.

—Dean L. Rockwell,
Chairman, Chapter Liaison Committee



This busy west-coast plant bought this 800-ton Cast-Master for large section parts. Photo, courtesy Alloy Die Casting Company, Los Angeles.



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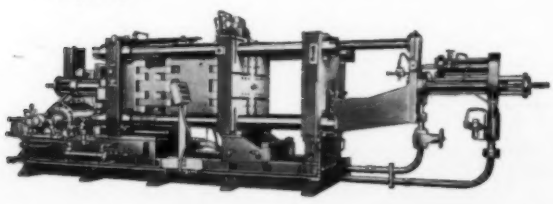

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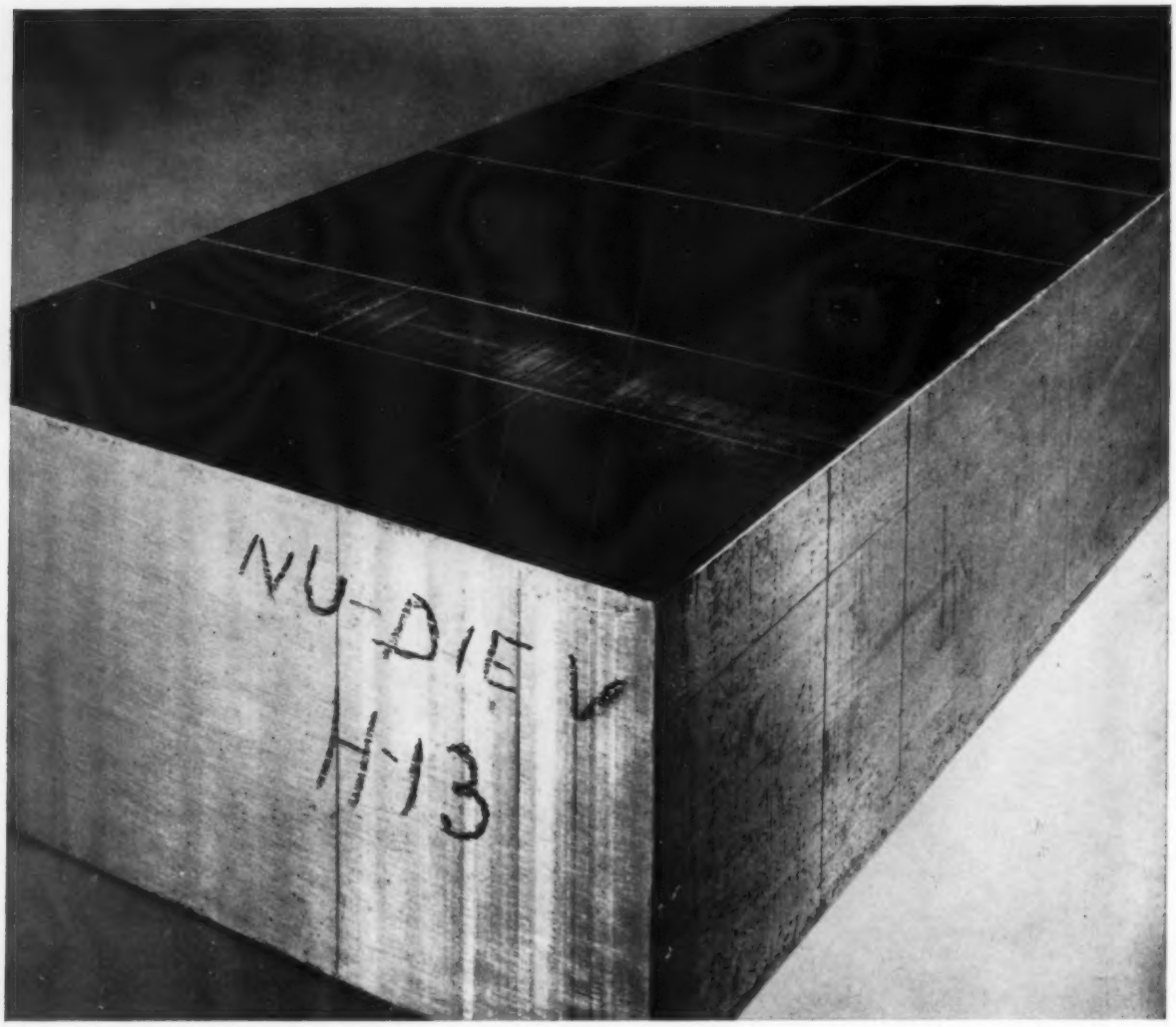

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Die Casting
ENGINEER

Developments in the Pressure Die Casting of Steel

By V. M. BELOV and S. A. KAZENNOV

THE PRESSURE die casting process is currently limited to the alloys of zinc, aluminum, and magnesium, and some brasses. Technical difficulties arise if the die casting of alloys of higher melting point is attempted. Recent work, however, has indicated the lines of development that must be followed if the pressure die casting of steel is to become a practical possibility.

Owing to the higher melting point, and the different mechanical and physical properties of steel as compared with the die casting alloys now in industrial use, specific limitations are imposed in connection with casting design. Because service conditions are severe, die life is short and the design of the part must be such as to enable the die to be made by a low labor and material-cost process such as hobbing. On account of the large thermal contraction of steel, high stresses may be set up in the component unless adequate draft is allowed. Draft of 1 deg. is necessary on side walls where there is likely to be severe contraction, and 0.5 deg. elsewhere.

The solidifying steel contracts around cores and projecting portions of the cavity and grips them tightly, and the force needed for ejection may reach tens of tons. As a result, surfaces normal to the die face quickly become worn at points where contraction is constrained. The corresponding casting dimensions may thus be altered, and this fact must be taken into account when setting tolerances. Holes of less than about 0.3 in. diameter should not be cored.

Castings should be so designed that the major part of the cast surface does not require to be machined. Where the gate joins the casting, on location faces, and at ejector pin positions, an allowance of 0.008/0.012 in. for grinding, or 0.020/0.040 in. for machining, should be made. Walls of steel pressure die castings should be not less than 0.080 in. thick, and should be uniform or—if varying—arranged so that the thickening section follows the solidification gradient. With this arrangement, the thickest section adjoins the gate. It is impracticable to produce castings with localized heavy sections free from shrinkage defects. Both finish and dimensional accuracy deteriorate as the die becomes worn.

Not all steels are equally suitable for pressure die casting. In particular, steels with 0.2 per cent C. are subject to cracking during solidification. The steels most suitable for the process are those with carbon contents up to 0.15 per cent, and with good plastic properties both when hot and when cold. Some alloy steels, including the chromium-nickel types, have good plastic properties and a low solidification shrinkage.

TABLE 1. RELATION BETWEEN CASTING THICKNESS AND HARDNESS OF "AS-CAST" TEST PIECE OF VARIOUS PRESSURE DIE CAST STEELS

Thickness of Test Piece, in.	Brinell Hardness			
	Steel 20	Steel 30	Steel 40	Steel 50
0.08	220	250	280	420
0.16	180	190	200	260
0.32	170	180	190	220

Steel pressure die castings are hardened by rapid chilling in the die, and the "as-cast" hardness increases with carbon content. This effect is shown in Table 1, which also indicates the inverse relation between section thickness and hardness. Similar results are obtained with alloy steels. The rates at which the die becomes worn and the shot-sleeve abraded at the forward end, are largely determined by the as-cast hardness of the component. From an operational viewpoint, therefore, the most suitable steels for pressure die casting are non-hardenable types with 0.15/0.2 per cent carbon content, austenitic steels of low hardenability, and special alloy steels of low final hardness. In selecting a steel, it is also necessary to take into account the tendency to oxidize when molten,

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which can result in off-grade castings and surface imperfections.

DIE DESIGN

TO OFFSET the limited life, die production must be cheapened by using quickly replaceable die blocks, by maximum standardization of all die components, and by hobbing the die cavities. A typical die for casting steel consists of two main members and an ejector mechanism, as seen in Fig. 1, the core portion being formed integrally with the fixed member and the cavity sunk directly in the moving member. Separate cavity inserts are not satisfactory, as the molten steel penetrates the joints between insert and block and causes early failure. Standard die blocks are used, which are capable of producing a variety of components within a given size range, and worn die members can be changed in about 10 min. Ejector pin replacement requires 5 to 7 min. Ejector housings are subject to rapid wear, and provision must be made for periodically drilling them oversize and fitting larger diameter pins.

DIE LAYOUT

THE HIGH melting point of steel, and the large solidification shrinkage, are the main factors which determine the positioning of the cavity in the die, the form and size of the runners, and the size and location of overflows. Casting temperature is appreciably above the liquidus, and the molten metal enters the cavity at between 1,600 and 1,620 deg. C. Initial die temperature is between 100 and 150 deg. C., and the temperature differential is therefore of the order of 1,500 deg. C. Consequently, conditions are not favorable for feeding additional metal into the cavity to compensate for solidification shrinkage, and gate location is therefore particularly critical.

Gates should be located at the heaviest section of a casting, and runners should be kept short, as indicated in Fig. 2, and should be of trapezoidal section. The runner should extend directly from slug to casting. Branched runners of the type used with light alloys are unsatisfactory. Cross-section of the runner

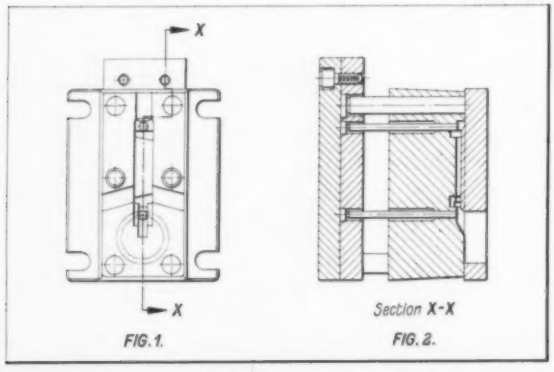

Fig. 1. A die for pressure casting a simple steel component

Fig. 2. Sectional view of the die in Fig. 1, taken on the line x-x

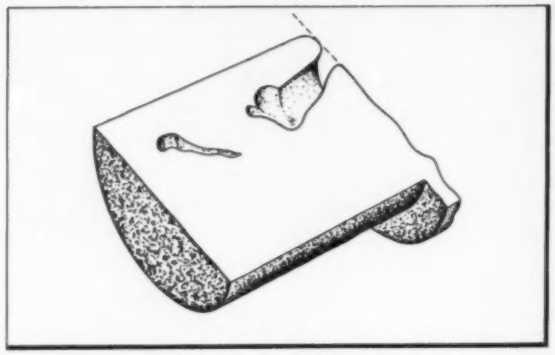

Fig. 3. To promote feeding during solidification, a heavy slug is desirable

should diminish in area from slug to casting. If these conditions are fulfilled, dense castings without shrinkage cavities can be obtained.

The volume of the slug plays an important part in the production of a sound casting. In this connection, attention is drawn to Fig. 3, which shows a section of a slug obtained when the die was opened before solidification was complete. Liquid metal has been

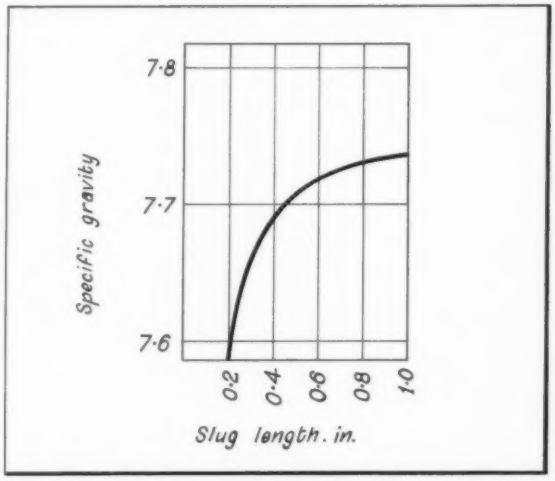

Fig. 4. Graph showing the effect of slug length on the density of the casting

expelled, leaving a cavity at the junction of slug and runner. It was not found possible to obtain a similar cavity in a shorter slug, because the latter solidified simultaneously with—or before—the casting that was being produced.

It was possible to show the effect of slug length on the solidity of the casting, by producing flat test pieces with various lengths of slug. The results, as shown graphically in Fig. 4, indicated that when the slug length was progressively increased from 0.200 to 0.800 in., the density likewise increased until it reached a constant value. This result is explained by the better feeding properties of the longer slug, all other factors being constant.

The other important factor in insuring freedom from voids is cavity venting during injection. Because

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of the large temperature differential between metal and die, the steel, on coming into contact with the cavity surface, solidifies instantaneously. Consequently, it is necessary to vent both from the far end of the cavity and from points adjacent to those portions that are the last to fill. Typical venting practice is indicated in Fig. 1, where one vent is provided opposite the gate, and two vents are located on the sides of the runner near the gate. Vents are from 0.004 to 0.006 in. deep, depending upon casting conditions. When pressure and injection velocity are increased, vent depth is reduced.

Steel die castings were first produced in Russia on a Polak 900 machine by a group of foundrymen under the leadership of E. I. Dunaev. Their work showed the practicability of the process, but it was found that the vertical shot-sleeve, characteristic of this type of machine, became barrel-shaped, with the largest diameter at the slug, after the first few shots. This effect was due to the localized heating, and shearing and ejection of the slug became impossible.

A machine with a horizontal shot-sleeve does not suffer from this drawback, but because of the large area of the sleeve which is in contact with the molten metal, greater superheating is necessary. This latter disadvantage, however, is not serious, and type 515 and similar machines have been found suitable for the die casting of steel.

MELTING AND FEEDING

THE use of holding furnaces is not practicable with steel, as the molten metal quickly changes in composition due to the oxidation of some of the elements (C., Mn., Ti.) and the fact that other elements are picked up from the refractory lining. Moreover, metal transfer from a holding furnace is attended by technical difficulties and the working conditions for the machine operator are unsatisfactory. An improved technique was therefore sought, and the best results were obtained by using a small induction furnace, with a capacity sufficient to melt metal for a single shot, attached to the fixed platen of the machine immediately above the shot-sleeve. Fig. 5 shows such an arrangement, designed for mounting on a 515 die casting machine.

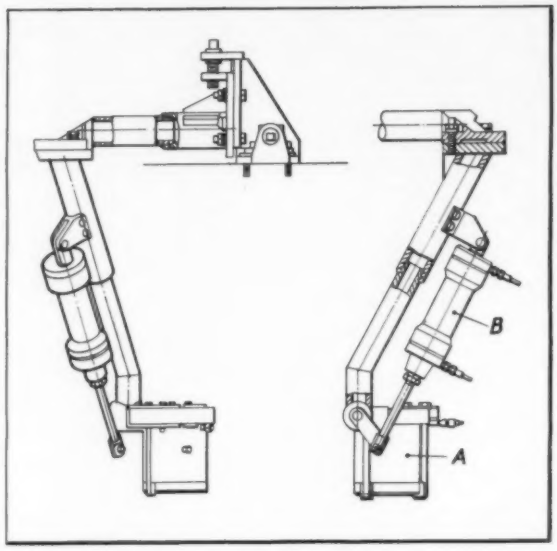

Fig. 5. Arrangement of induction melting furnace for the Polak 515 machine. The furnace pivots from the vertical to the horizontal position

A billet measuring 0.8 to 1.6 in. diameter, and weighing from ten ounces to 2¼ lb., is placed in the melting chamber *A*, while the latter is in a horizontal position. On pressing a button, air is introduced into the cylinder *B* at a pressure of about 60 lb. per sq. in. The furnace is thus turned to the vertical position and the induction coil is energized. With the equipment described, from 50 to 90 sec. is required to raise the blank to casting temperature, depending upon its weight. Under controlled conditions, melting time is constant to within ±5 sec. As soon as the steel has melted, the furnace is again turned to the horizontal position and the charge of metal is transferred to the shot-sleeve. The furnace is so mounted as to reduce the transfer distance to a minimum.

Composition of the furnace lining is selected according to the type of steel to be die cast, and the method of lining is the same as for conventional induction furnaces. Before starting to cast, the lining is cured by melting a charge of metal of sufficient volume to fill the whole melting zone, with the gen-

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REED-PRENTICE
DIE CASTING NEWSLETTER

When rejects go up... check your gating and design first.

Gating of die casting dies is perhaps one of the most misunderstood aspects of the industry. While some experienced engineers can come up with a very good gating system after studying a casting, too often gate patterns just seem to "happen that way."

The reason: gating's function is misunderstood and thus misapplied.

Because die casting is a high-speed, high-production process, it is generally deemed desirable to keep the connection between the runner and the casting as small as possible. This makes degating an easier operation, one requiring unskilled labor.

Fact... and fiction

While ease of degating is a definite consideration, the most important aspect of gating a die casting die is to provide a metered entry of the metal, preventing its entering the die faster than air can be vented. For vents must be limited in size to an area no greater than will freeze off without splitting.

Gates are often used to try to build up pressure on the metal, but this is a fallacy. Pressure build-up occurs *in the runner*. No matter what the conformation of the gate, pressure in the casting does not build up *until* terminal filling has occurred.

Pity the machine

As far as the effect on machine performance is concerned, gating design can—and often is—carried to a ridiculous extreme. Gates are choked off with no consideration of the velocity of the metal, volume of metal, time of fill, or any factor except that the operator must be able to break the gate off by hand... quickly and easily. The machine is expected to have high speed, substantial pressure, and *lots* of it.

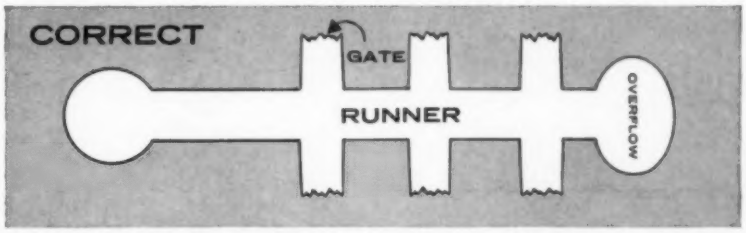
This is fine, but often it doesn't work. Too many castings have defects, rejects are up, and where do you place the blame? All too often, it's the machine's fault, or is it? Take another look at that gating design, and at the runners.

What runner pattern?

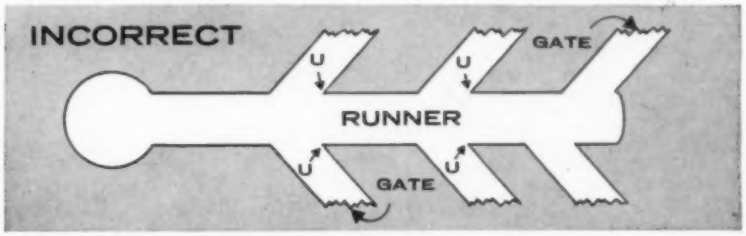
A runner is more than a means of conveying the metal to the gate. Consider it a high-pressure, smooth-walled conduit, with either a constant or reduced area that prevents expansion of the metal. Its size and conformation *are* important.

The simplified sketches here show a sound runner design and one other system which, though commonly used, tends to produce surface defects on castings.

If you are having casting trouble, why not check with your nearest REED-PRENTICE Sales Engineer. He'll be glad to consult with you.



With a straight runner, metal rushes to fill the overflow first, then the entire runner. It expands out from the center in a continuous flow, with equal force to both sides.



When a runner branches out at an angle, its upper edges (U) tend to catch a partial flow of metal. Small amounts are injected into the cavity before filling volume is available, causing a cold shot and rough, porous castings.

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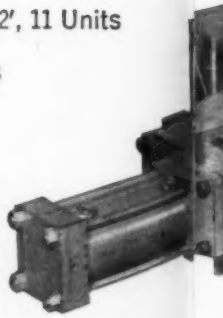

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The rather large casting shown is a transmission housing and was produced in the die illustrated. This gives further evidence of the wide range of complex, as well as simpler work done with Efficient's superior facilities.

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erator set to give the longest possible melting time. After curing the lining, one or two washing melts are made before casting starts. If a ring of solidified metal forms during normal operation at the top of the melting zone, the washing melts are repeated.

The billets are prepared by shearing measured lengths from rod of suitable analysis. Blank weight includes an addition to the casting weight of about 7 oz.—when using a 1.6-in. diameter plunger—for the slug. Optimum melting conditions must be determined empirically. Slow melting reduces productivity, but very fast melting causes overheating of the steel, which may then weld to the shot-sleeve or die cavity. In operation, this melting technique has proved reliable, and it can be recommended for industrial use.

VACUUM DIE CASTING

WHERE the requirements for the component are such that the presence of voids is not permissible, steel die castings may be made under vacuum. The entire die is then mounted within a vacuum chamber, and the air pressure in the surge tank is reduced to 1 mm. of mercury before starting to cast. The air is evacuated from the closed die by way of the runner and shot-sleeve, and a fall in pressure within the cavity to between 20 and 10 mm. of mercury is obtained in 1 sec.

INJECTION

WHEN injecting the molten steel into the die, the replaceable plunger tip becomes heated and expands. A clearance of 0.002 to 0.004 in. is therefore provided between the plunger tip and shot-sleeve, and the tip is water-cooled. The flow of water is regulated by a valve controlled by a thermocouple located within the tip. To prevent metal from welding to the edge of the pouring hole in the shot-sleeve, a ceramic bush is fitted as shown in Fig. 6.

Investigation has established the effects of the main operational variables upon the pressure die casting of steel. These variables are: slug thickness, specific pressure and injection velocity. The effect of variations in casting temperature (for which, in any event, the range is small) and of the shape of the casting have not been studied. Die castings were made at specific

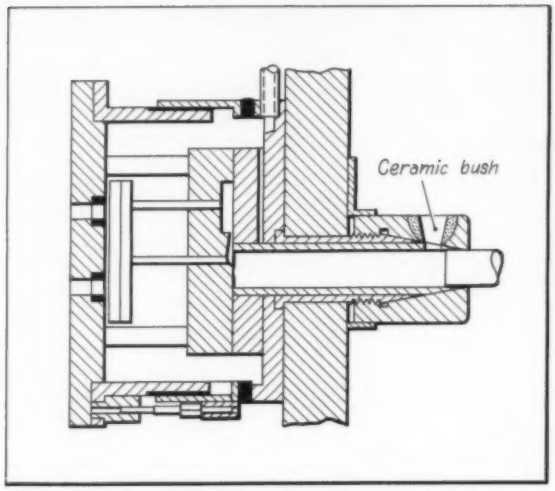

Fig. 6. Hooded die for vacuum die casting

pressures of 7,000 and 14,000 lb. per sq. in., with a plunger of 1.6 in. diameter. Plunger speed was controlled by modifying the accumulator pressure and by means of valves on the machine, and the actual speed was determined by high-speed photography. The effects of the process factors were determined for flat test pieces 0.080, 0.160 and 0.320 in. thick. Die layout for these test pieces is shown in Fig. 7.

The effect of the gate depth upon the density and mechanical properties of die cast steel test pieces in 1Kh18N9T* is indicated in Fig. 8. In each case, the values shown for density, tensile strength, and elongation are averages from 25-30 specimens. As will be noted, the gate thickness has little effect upon the properties of the 0.080 in. thick test pieces, which show much the same values whether the gate is 50, 75 or 100 per cent of casting thickness. These thin test pieces could not be cast with a gate of only 25 per cent (0.020 in. deep) of casting thickness.

Thicker specimens are more sensitive to the gate/casting ratio, and it was found that the optimum ratio was 3 to 4. This ratio was therefore standard-

* A stainless, acid-, scale- and heat-resisting steel of the following percentage composition: C, 0.12 max.; Si, 0.8 max.; Mn, 2.0 max.; Cr, 17.0—20.0; Ni, 8.0—11.0; Ti (C—0.03) × 5 to 0.8 max.; S, 0.03 max.; P, 0.035 max.

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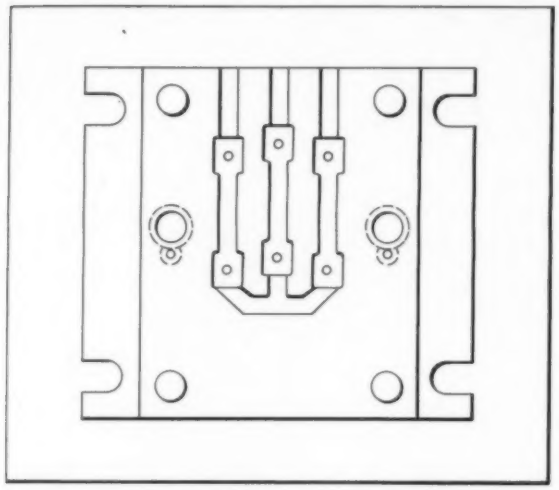


Fig. 7. Die for producing flat test bars in three thicknesses

ized when investigating the effects of specific pressure and plunger speed. Results obtained from the latter tests are summarized in Figs. 9 and 10. Broadly, the density, tensile strength and elongation increase with increasing injection pressure. Density and tensile strength are both greater for the thinnest (0.080 in.) than for the thicker test pieces, but the elongation shows an opposite correlation. This improvement in density and strength with higher pressure is attributed to better feeding while the casting is solidifying. The effect of increasing the plunger speed, on the other hand, is to decrease both density and mechanical properties, particularly with the thicker specimens.

In consequence, it is recommended that the die casting of steel be carried out at high pressure but with low filling speed. On the type 515 machine the maximum specific pressure available is 14,000 lb. per. sq. in., corresponding to an accumulator pressure of

TABLE 2. MECHANICAL PROPERTIES OF PRESSURE DIE CAST STEEL

Property	Specification Requirements	Without Vacuum	With 20 mm. Hg. Vacuum
Tensile strength, tons (short) per sq. in.	32	39.8	36
Elongation, per cent	25	37	39

70 atmospheres. Minimum plunger speed is 16 in. per second. The effect of die evacuation is indicated in Fig. 11 and Table 2. The vacuum cast pieces were produced with a 3/4 gate/casting thickness ratio and at various injection speeds, and the values indicated are the averages for 50-60 measurements in each case.

It will be seen that the relationship between density and mechanical properties is broadly similar for both conventionally cast and vacuum cast pieces of 0.160 in. thickness. It will be noted that with vacuum the density is improved—although it does not reach that of rolled steel—whereas the strength is reduced, and this effect has not been fully investigated. The mechanical properties of the vacuum cast test pieces nevertheless satisfy the requirements of the relevant State Standard, provided that the optimum pressure and injection velocity are employed.

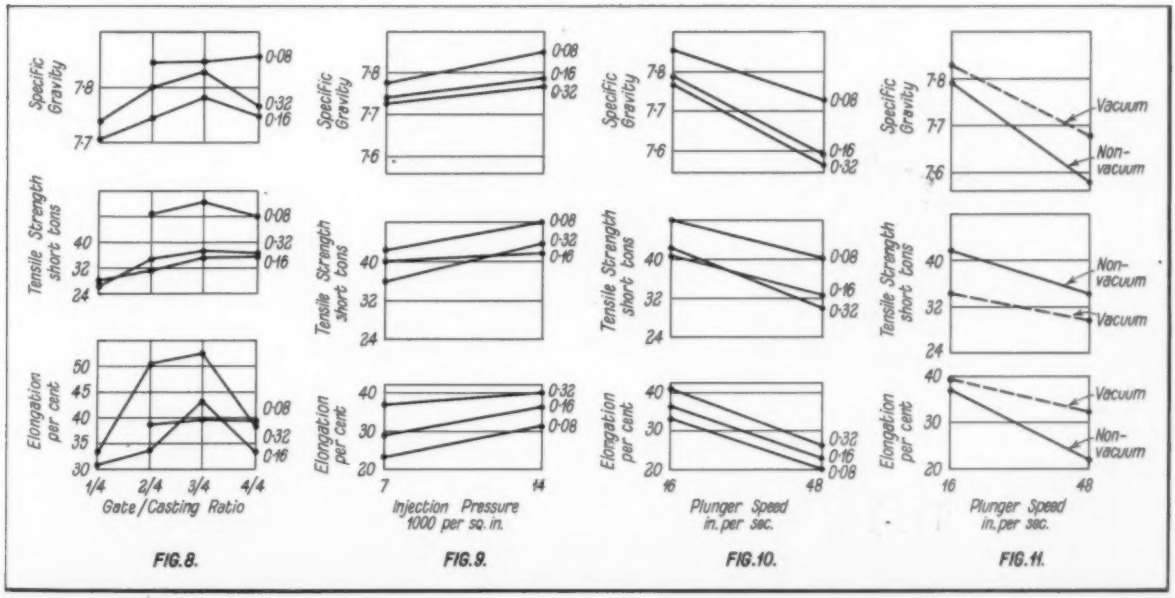
(Continued on Page 30)

Fig. 8 Graphs showing variation of mechanical properties with changes in ratio between gate depth and casting thickness

Fig. 9. The effect of injection pressure on mechanical properties

Fig. 10. Increased plunger speed results in inferior mechanical properties

Fig. 11. A comparison between the properties obtained by conventional (non-vacuum) die casting and by the vacuum method



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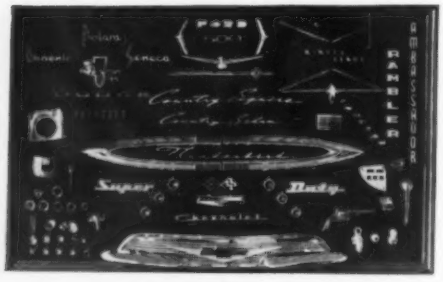

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DONALD L. COLWELL

ALLOYS FOR DIE CASTING

DIE CASTINGS are commonly made in alloys based on tin, lead, zinc, aluminum, magnesium, or copper. Even gray iron is cast in permanent molds, as described by McClelland before the Die Casting and Permanent Mold Division of the American Foundrymen's Society.[1] By far the greatest proportion of commercial die casting today, however, is in the field of zinc base and aluminum base alloys and this discussion will be limited to recent developments in these two alloys and their processing.

The first general specification for zinc base die casting alloys was that of the American Society for Testing Materials in 1931.[2] By co-operative tests Committee B6 of the ASTM has established the necessity for close limits on the harmful impurities tin and lead and has revised these specifications from time to time. The latest issue of this specification, B86-57T, is the standard today.[3] This specification contains two alloys, AG40A and AC41A, the latter containing a small amount of copper. Both of these have maximum impurity limits of 0.007% on lead and 0.005% each on tin and cadmium. The International Standards Organization has just given tentative approval to ISO/TC18[4] as international standards for these two alloys with the lead maximum at 0.003%, the tin maximum at 0.001% and the cadmium maximum at 0.003%. In addition to this, iron is limited to 0.05%, and, in the number 3 alloy, copper is limited to 0.03%. There is a lack, however, of strong indication that these narrower limits are essential.

One of the aging tests of the ASTM was exposure of test bars at outdoor sites at New York, Altoona, Pa., and State College, Pa., and at indoor sites at Coco Solo, Panama Canal Zone, and at Tucson, Ariz. Committee B6 has just reported on the results after twenty years exposure at these sites.[5] Three alloys were exposed, the two mentioned above and also AC43A with 3% copper (No. 2), which has since been dropped by ASTM. The results in tensile strength and elongation are shown in *Fig. 1* and in Charpy impact strength and dimensional change are shown in *Fig. 2*. After twenty years exposure, AC43A (No. 2) shows a considerable dimensional change and a major drop in impact strength and elongation; AG40A (No. 3) shows no growth and retains its impact strength and elongation the best of all. AC41A (No. 5) is intermediate. AG40A, therefore, remains the most stable zinc base alloy in commercial use today.

The aluminum alloy most commonly used is No. 39, based on the old Ordnance Department specification AXS679. The last revision of this specification allowed a maximum of 0.6% zinc. After co-operative investigation this was raised to 1% and was so specified by the American Society for Testing Materials and the Society of Automotive Engineers as SC84A and SAE 306 respectively.[6, 7] The ASTM has now increased the zinc maximum in this alloy to 3%,[8] and similar action is pending before the SAE. It is expected that government specifications will eventually be brought into line also.

Again this change was not made without considerable testing done by the alloy producers and the ASTM. A co-operative test of the latter exposed test bars of SC84A with zinc contents varying from 0.25 to almost 3.0% at three different outdoor locations.[9] The first of these was on a rooftop in New York and the second two were at Kure Beach, North Carolina, one site 80 feet from the ocean and the other site 800 feet from the ocean. The results after six years' exposure at two of the three sites have just been reported.[8] The 80-foot bars were lost in a hurricane before the six years were up, but their trend was not significantly different from that of the 800-foot bars. Tensile strengths, yield strengths, and elongations are plotted in *Fig. 3* and compared with the initial values on the same series of bars. The elongations at both locations dropped with time and the yield strengths at both locations increased due to age hardening of the alloy, and this effect was the same in all the various zinc contents. The ultimate tensile strength at Kure Beach dropped with time a little more than that at New York, due to the greater effect of the salt water, but here again the different zinc contents had no effect. The performance of these bars under this severe corrosion exposure was much better than the Committee had expected. The usual 1, 5, 10, and 20 year test periods were shortened to 1, 3, 6, and 12 years because of the suspected rapid deterioration of the bars, but as can be seen from the six year values

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Mr. Donald L. Colwell is vice president of the Apex Smelting Company, Cleveland, Ohio. *This paper was originally read at a meeting of the Central Indiana Chapter of the Society of Die Casting Engineers, September 9, 1960.*

there was very little change in properties, and the zinc content had no effect on this change.

IT has been stated that the corrosion resistance of aluminum die castings with a copper content is inferior to the corrosion resistance of copper-free aluminum die castings. Co-operative work by the ASTM indicates essentially no difference between high purity grades of S12A (No. 13), S5C (No. 43), and SG100A (No. 36) and those of commercial purity, the latter containing up to 0.6 copper and with higher zinc, manganese, and iron contents.[10,11]

An accelerated corrosion test of these three alloys of commercial purity compared to SC84A (No. 39) of commercial purity by alternate immersion in a sodium chloride solution containing hydrogen peroxide indicates similar losses in tensile strength, yield strength, elongation, impact strength, and weight for all four alloys.[12] The results are shown graphically in *Fig. 4*, and actually the highest losses in properties are those of the SG100A (No. 36) alloy. The SC84A (No. 39) was slightly better, and losses in properties of S12A (No. 13) and S5C (No. 43) were somewhat less. It can be seen from the curves that they all were similarly affected, and it is doubtful that the differences are significant for most applications.

The die casting process is essentially a repetitive process for the rapid production of identical parts. In this process it is essential that the variables be accurately and definitely controlled, and often the control of the metal variable is not what it should be. All common specifications have ranges of alloying elements and maxima for impurities, but mere conformance with the composition specification does not insure identical materials. The reputable smelters work well within a given specification and control impurities and alloying elements alike to much narrower limits than the specification allows. To insure composition uniformity therefore, it is well for the die caster and his supplier to get together and agree on a specific composition. It is also desirable for the die caster to use ingot from only one or two quality suppliers who have been found to give consistent control of composition. To buy cheap ingot from different suppliers at different times is unfair to the production department trying to maintain uniform production, and it also leads to expensive nonuniformity and probable losses in production and in quality of product. It has also been found that more uniform production conditions are obtained when the ingot is made from aluminum that has been subjected to previous processing of one kind or another, and then accurately blended into casting ingot of the required composition. It has been well established that die casting ingot of good composition made from scrap gives superior results in the die casting shop.

Another variable affecting die casting production is porosity. Fortunately for the die caster the solubility of hydrogen in aluminum is practically nil at the usual casting temperatures so that hydrogen pickup due to moisture is not as serious as it is in other aluminum casting methods where casting temperatures are higher.[13] Porosity in die castings may be due to trapped air, but it is more often due to trapped oil. Unfortunately a certain amount of lubrication of the plunger and of the die ejection mechanism is necessary, but excess lubrication, particularly in the plunger well, is sure to lead to casting porosity. If a porous casting has been sectioned through a porous area and allowed to stand over night, a drop or two of oil can often be seen on the surface. This oil bleeds from the pores when the pressure is released by the cut and shows what caused the porosity.[14] It is desirable, therefore, to meter the lubricant in the plunger well and also to use a volatile vehicle for the die lubricant and to keep both to an absolute minimum.

The vacuum casting process tends to remove some of the gases developed by excess lubrication, but it is much more certain and much more economical to prevent the formation of these gases than to try to remove them by vacuum after they have formed.

Non-metallic inclusions in a die casting are major causes of difficulty in machining. The source of such inclusions can usually be traced to the melting and handling practice of the aluminum. Iron pots, crucibles and open hearth furnaces should be kept scrupulously clean. Aluminum often splashes on these walls and oxidizes, and while this oxide is soft when first formed it soon bakes to a hard refractory oxide under the heat of the furnace.[15] When this gets into the

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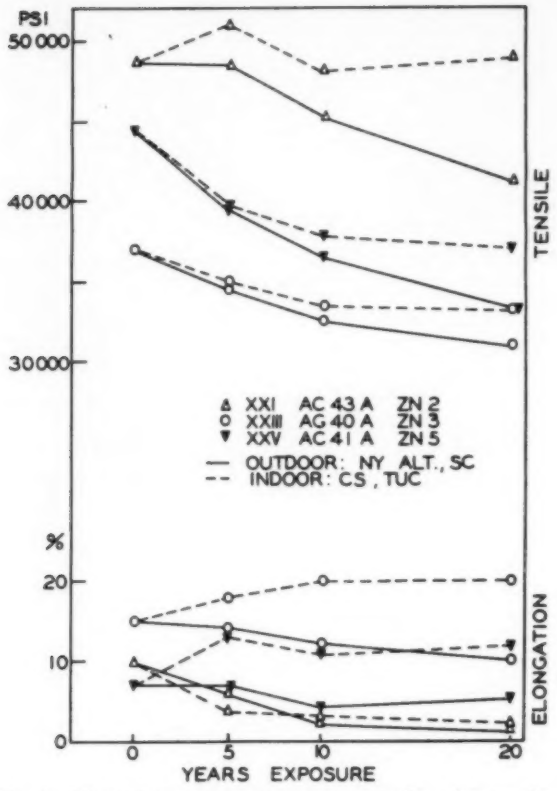


Fig. 1. Effect of twenty years exposure at various sites on the tensile strength and elongation of die cast zinc alloys.

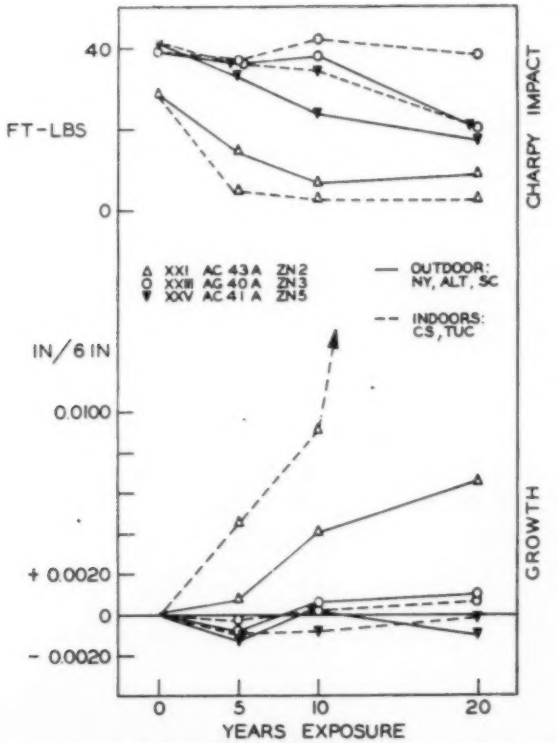
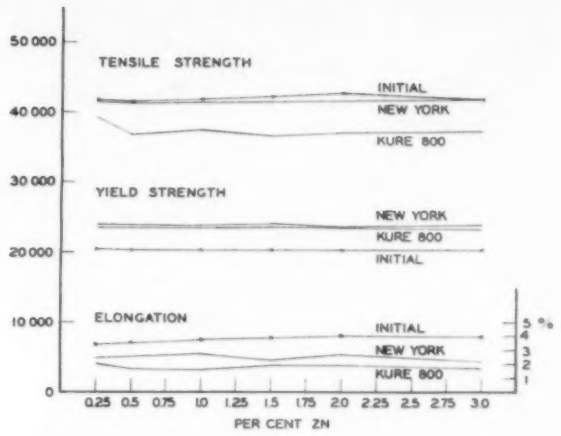


Fig. 2. Effect of twenty years exposure at various sites on the Charpy impact strength and growth of die cast zinc alloys.



SC84A WITH INCREASING ZINC AFTER 6-YEAR EXPOSURE AT TWO SITES

Fig. 3. Effect of six years outdoor exposure on die cast SC84A with various zinc contents.

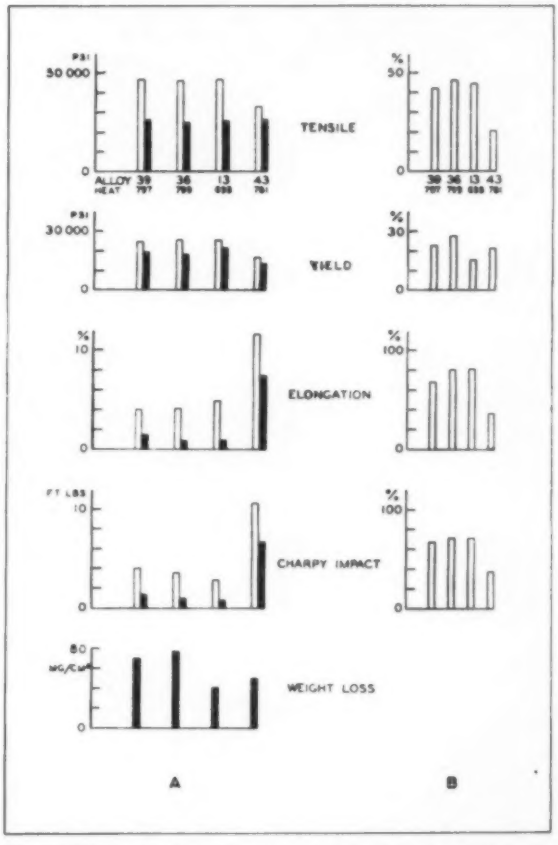


Fig. 4. Effect of 15 days alternate immersion corrosion on mechanical properties and weights of four standard die casting alloys. (A) Before (open bars) and after (solid bars) 15 days corrosion. (B) Per cent loss in properties after 15 days corrosion.

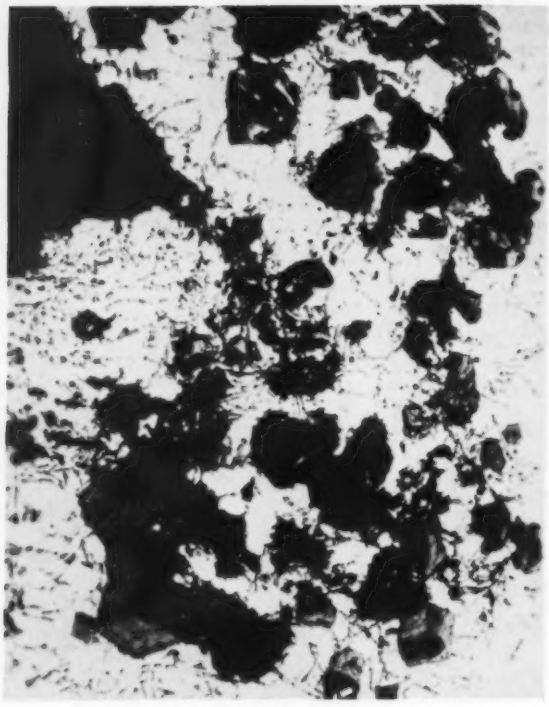


Fig. 5. Fused aluminum oxide particles (black) and plates of Al Fe Si Mn. complex (gray) in normal cast structure of SC84A. X75

metal it can rapidly wear or even nick a cutting tool. An example of such oxide inclusions is shown in *Fig 5*.

MOLTEN aluminum acts somewhat like a detergent solution in a dishpan. Any agitation of this solution causes a foam or froth, and agitation of molten aluminum has a similar effect. When aluminum is being transferred by pouring, care should be taken to keep the ladle and receiver at almost the same level so that there is no appreciable drop of the molten stream. Velocities in launders should be slow and the flow quiet. When hand pouring on a cold chamber machine the ladle should brush back the surface oxide as it is dipped in and filled with metal from below the surface. In pouring into the well the drop should be at a minimum. Automatic ladling devices which take the metal from below the surface of the holding furnace and deposit it in the well with a minimum drop are excellent for reducing this frothing action.

Another source of non-metallic inclusions can be the inclusion of cell feed in metal which is made directly from the aluminum reduction cell in an aluminum refinery. Such cell feed or cryolite can be removed by proper cleaning, but traces often remain in such cell metal. This cell feed acts like a flux as the metal impinges on the die surface at high velocity and can aggravate a tendency to solder.

Another type of inclusion found all too often in die casting plants is the aluminum - iron - manganese - silicon complex formed at the low casting temperatures.[16] At a temperature of 1200°F or less for SC84A alloy a local chilling action from cold metal charged freezes metal around the charge, which is never completely remelted at this holding temperature. This complex collects at the bottom of the furnace as a sandy layer shown in *Fig. 6*. If this gets into the casting it produces a large number of hard spots distributed through the metal, and tools are worn or nicked by these inclusions. Furthermore, when part of the composition settles out, the remainder is changed in composition, and thus the alloy being put into the well is not the same as that originally charged. A reduction in the iron and manganese content caused by sludging would also enhance the soldering action when the remaining liquid metal, lower in iron and manganese, is cast. A sketch of how this sludging occurs is shown in *Fig. 7*. The remedy is to charge the holding pot only with molten metal and to melt both ingot and gates and sprues in a separate furnace at a temperature around 1350°F. By frequent charging of hot metal into the holding pot the temperature of the holding pot is not raised unduly and sludging is eliminated.

Recommendations to avoid trouble with aluminum in the die casting operation can improve uniformity and reduce difficulties due to rejected castings. The purchase of clean uniform ingot of closely controlled composition from only one dependable source is recommended. If another source is desired for competitive reasons, the same controlled quality should be secured

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Fig. 6. Section of sludge; it settles in layers. X40

and metal from different sources should not be alternated on the same job. It is desirable that this ingot be produced by remelting several times such as occurs when scrap is used. The alloy will then be more nearly in equilibrium and its full potential secured. It should be carefully fluxed and cleaned at the melting furnace. If a significant scum accumulates on the holding furnace a small amount of flux should be used once or twice during the day to separate the molten alloy from the oxides.

Lubrication of plunger well should be kept to an

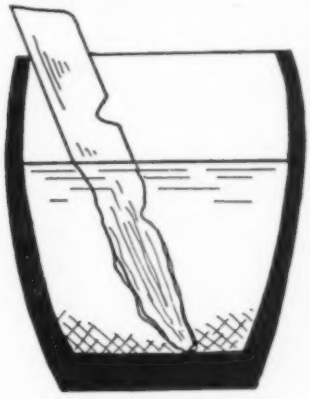

Fig. 7. Cold ingot charged into molten aluminum alloy induces sludging.

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absolute minimum by metering at the well so that only a minimum uniform quantity of grease is applied at each shot. A die spray for lubricating ejector mechanism and cores should be kept to a minimum, and a light vehicle which evaporates immediately is desirable. The total vent area should be approximately one half the gate area and should be located so as to pull the metal into the farthest corner of the die.

All transfer of molten metal should be done quietly so as to avoid foaming. If the metal fall can be kept down to a maximum of two or three inches agitation should not be too serious. If drops of a foot or more are required the foam and scum formed in the holding furnace should be fluxed and removed periodically.

In conclusion, it should be emphasized that the successful die caster is he who reduces the number of variables in his process to the point where castings are produced hour by hour and day by day with a uniformity comparable to that of a machine tool operation.

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CORRECTIONS, PLEASE

In "Alloy Control for Zinc Die Castings," by J. L. Kimberley and Ernest W. Horvick, *Die Casting Engineer* for May 1961, an error occurred on page 33. Figure 1, illustrating the difference in properties in bending for pure and impure die castings, was printed upside down. The figure shows the successfully bent casting as being impure zinc, while the casting which failed is shown as pure zinc.

We regret the printing error and appreciate Mahlon E. Wood, Market Development Engineer of the American Zinc Institute, calling it to our attention.

In the Chapter News, page 24, the account of J. B. Kelley forming a new company, Die Casters' Services, Inc., appeared under Cleveland Chapter News. This should have been printed as News of the Industry, and we apologize to E. J. Hinkel, Secretary of the Cleveland Chapter, for the error.

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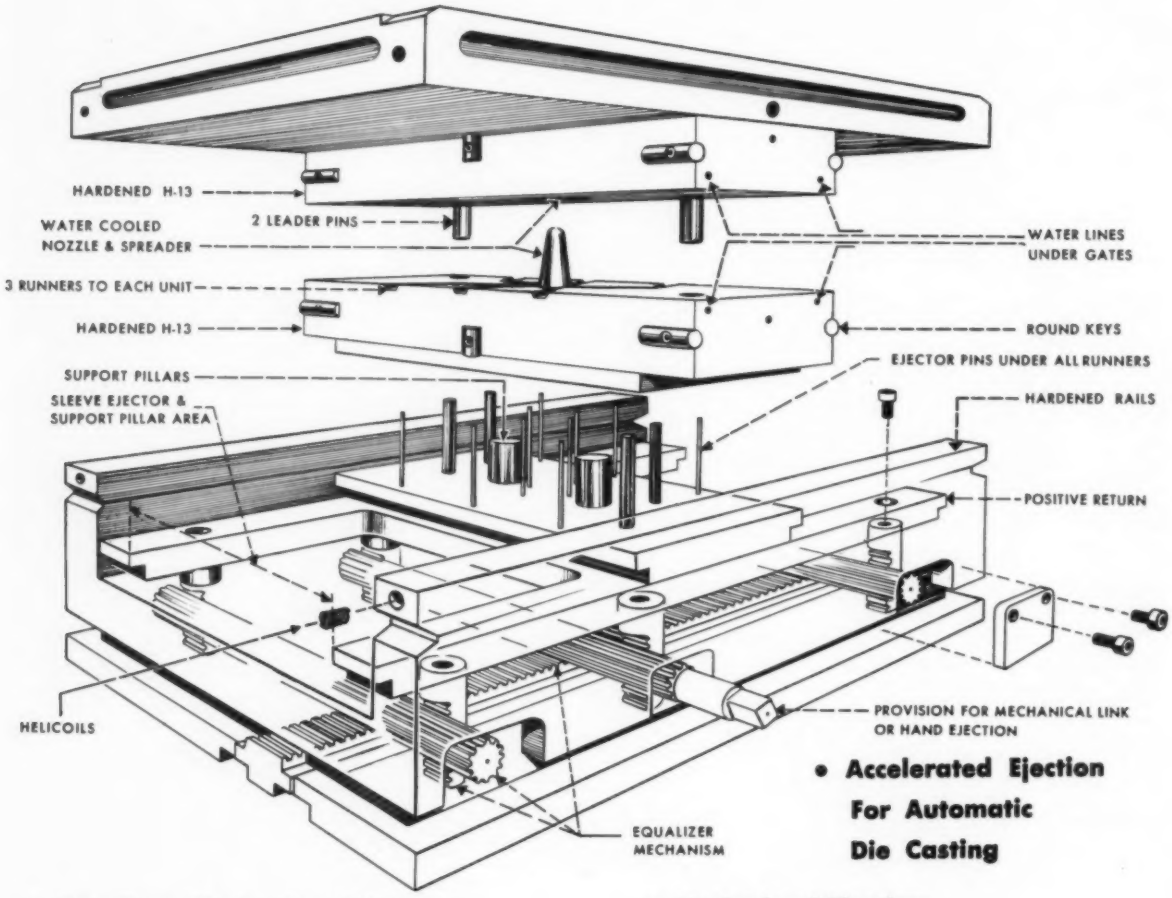

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Art Column

ART AND AUTOMATION

By Earle W. Rearwin

IT is readily admitted that automation of an ART is extremely difficult; therefore, when we attempt to automate the die casting process we must first convert the abstractions of an ART into the readily controllable variables of a science.

From observation and study of many automatic die casting operations one fact stands out above all others . . . the automatic operations that are successful are those from which most of the ART has been removed.

One of the outstanding results obtained in these successful operations is the reduction of rejects. Once the necessary care has been taken to automate a die casting machine or a die, this by itself assures a more uniform operation and a more consistent product.

Automation permits a constant cycle, thus assuring even heat distribution in the die. In the case of casting zinc, the rate of metal flow is maintained as a constant and thus the temperature of the die is held to closer limits. In the case of aluminum, automatic cold chamber lubrication now becomes a necessity; thus application of lubricant is no longer a paint brush procedure, but must be maintained constant as to amount and form. When casting aluminum in automatic cycle, the ladling must also be automatic. Any good automatic ladling device is a great improvement over hand ladling.

It is true that several automated operations have been failures. I have not seen all of these, but those I have observed have failed due to improper attention to maintenance of close limits on the variable factors. In other words, the ART has remained and has refused to become automated.

In many cases excellent results have been obtained by only partly automating the operation, where die blow-off is accomplished by automatic means and die release material is metered and applied automatically. If the casting is aluminum, then the cold chamber is fed by a metered amount of lubricant and the metal is ladled either by pumping or by sucking it up into the chamber using a vacuum arrangement.

The operator simply removes the casting, watches the machine, in-

(Continued on Page 26)

Earle W. Rearwin has been appointed president of Southern Die Casting and Engineering, according to James H. Millis, President of Adams-Millis Corporation, High Point, North Carolina. Mr. Rearwin, a mechanical engineer, brings 24 years of experience in the die casting field to Southern Die Casting. He will remain on the engineering staff of Reed Prentice in an advisory capacity.

Earle W. Rearwin

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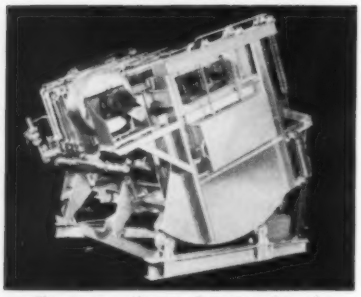

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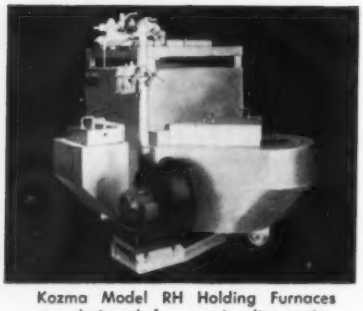

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INDUSTRY NEWS

JAPAN MAY IMPORT DIE CASTING UNITS

From *Metalworking News*

TOKYO—Intention of Japan's automobile manufacturers to develop new models with lighter die-cast parts may open a new import market for die casting machinery from the United States and Europe.

Major Japanese die casting machine makers are now interested in supplying their products to automobile manufacturers, to meet automobile makers' intentions to manufacture lighter engines, transmissions and other parts, trade sources say.

Die casting machines have been widely used for parts for motor bicycles. However, die casting machine makers are now preparing larger types of machinery with 1000 tons or 2000 tons capacity to manufacture automotive parts for four-wheel cars.

Die casting machine makers and automotive manufacturers are also considering purchase of those large types of die casting machines from foreign countries, these sources say.

ART COLUMN

(*Continued from Page* 26)

spects the casting, breaks or shears the gates and starts the casting on its way to machining or finishing operations.

If the casting is very heavy it is, of course, removed by mechanical means.

This type of operation permits the operator to be a machine operator, not a machine. It allows him to control his result and correct any fault as soon as it is detected. When he is properly trained he can produce high quality castings consistently.

These operations are minimizing the cost factors in die casting by reducing rejects, by eliminating extra handling and by protecting castings from stacking damage.

Through use of automation concepts it is possible to control ART. If you cannot automate completely, then at least have ART work for you in the areas that *can* be controlled economically.

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CHAPTER NEWS

NORTH CAROLINA

15 We in North Carolina are pleased to announce the formal organization of Chapter No. 15 of the Society of Die Casting Engineers. Meetings of May 16 and June 28 brought good attendance and enthusiastic interest, and we are now in business.

At the May organizational meeting 31 die casters and guests heard John MacLaren, National President, speak on the "The Role of SDCE in American Industry." Other speakers included Earle Rearwin, National Vice-President, whose topic was "Technical Considerations in Die Casting," and John Weber, Southern Die Casting and Engineering Co., who greeted those attending and outlined plans for formation of the new chapter. He also introduced Joe Elkins and Helmut Gebhardt, both National Directors of the Society, and Milton Harmon, Chapter Organizer.

In June 35 men met at Schraft's Restaurant in High Point for dinner and fellowship before hearing Jim Kelley, Die Casters' Services, Inc., give his provocative and stimulating talk "Why Do It the Hard Way?" An enthusiastic question and answer period followed.

Officers elected for the coming year were: Chairman, John Weber, Vice President and General Manager, Southern Die Casting and Engineering Co., High Point, N.C.; Secretary-Treasurer, Harold Lord, Westinghouse Electric, Raleigh, N.C.; Trustees, W. H. Needham, Southern Die Casting; Ben Goldman, Carolina Metals, Reidsville, N.C.; and Ed Flowers, Westinghouse Electric.

—Harold Lord, Secretary

DETROIT

1 The annual Golf Outing, held at Glen Oaks on July 1, was a huge success with some 208 die casters and guests taking part in the day's activities and festivities.

Golf, horseshoes and cards preceded a delicious steak dinner in the evening. Pete Sanders, Chapter Chairman, presided.

Carl Barnthouse, Jr., presented the major awards: Ted Stevens, low net of 72 in golf, Bob Smith, whose tee shot was in and out of the cup, stopping 2 inches away; Ping Ianitelli, longest drive, 325 yards. Over 180 miscellaneous gifts, ranging from a complete set of cubs to golf balls donated by vendors, were given out as door prizes. The Detroit Chapter thanks all donors who helped make the affair so successful.

—Bob Smith,
Chapter Correspondent

GRAND RAPIDS

3 The Grand Rapids Chapter staged its annual Golf Outing on June 20, at the Grand Rapids Country Club, where a great time was had by all. The lucky, though not necessarily the best, golfers received prizes following a fine steak dinner.

Next meeting in the fall. See you all then. —Carl Neuendorf,
Chapter Correspondent

(*Continued on Page* 28)

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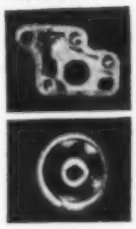

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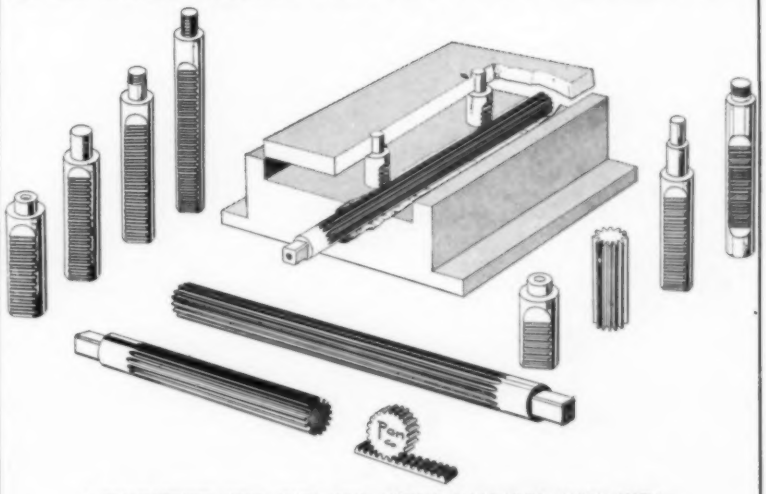

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CHAPTER NEWS

(Continued from Page 27)

TOLEDO

4 "Ladies Night" was the feature of the June dinner-meeting of Chapter No. 4 when a large crowd of die casters and their ladies enjoyed the color film, "The Society of Die Casting Engineers' 1960 European Tour". So successful was the program that all agreed that "Ladies Night" must be a yearly affair.

Installation of the 1961-1962 officers preceded the program. The new officers are:

Chairman, Ralph Malcolm, Chevrolet Transmission Plant; Vice-Chairman, Robert Allen, Schultz Die Casting Co.; Secretary, David Klotz, Carpenter Steel Co.; Treasurer, William Chapman, Dura Division; Librarian-Historian, William Noel, Latrobe Steel Co.; 3-year Trustee, Norman Leach, Norman Leach Associates (also National Director); 2-year Trustee, James Sutton, Dura Division; 1-year Trustee, Rolland Fulton, Chevrolet Transmission Plant.

—Robert Allen,
Chapter Correspondent

CLEVELAND

6 Ray Dunn, Lindberg Engineering Co., gave an interesting and informative talk to a record turnout of more than 70 members and guests at the June meeting. His topic, "Practical Aluminum Melting Techniques," supplemented by slides showing various holding and melting furnaces, was extremely well received and was followed by a provocative question and answer period.

Among the guests was L. G. Burke of the Aluminum Co. of Canada, Ltd.

This was the last meeting of the current season and all will be welcomed to our annual Clambake in September.

—Ed J. Hinkel, Secretary

INDIANA

25 Two interesting meetings at which timely and stimulating topics were presented have featured the last two gatherings of our chapter.

In April, John Weber of the

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CIRCLE 26 READERS SERVICE CARD

CHAPTER NEWS

(*Continued from Page 28*)

Southern Die Casting and Enginering Company of High Point, North Carolina, offered his fine presentation on "Sonics in Die Casting."

The May meeting featured a talk on "Processing, Developing and Heat Treating of Tool Steels" by C. F. Christopher of the Blaw-Knox Company. A lively question and answer period followed.

The final event of the Society year in Indiana will be a golf tourney and outing at the Pendleton Country Club, July 22, with prizes, food and fun for all. Tee-off time between 9-10 a.m.

Following the summer break, we'll see you at our next regular meeting on the second Thursday in September.

—Gene R. Vierling,
Publications and Promotions

PROMOTING INTEREST

Chapter No. 25 in Indiana has developed a little wrinkle that has improved attendance and interest in monthly meetings. It is called "Coffee Talk."

The chapter technical committee, headed by Bruce McPherson, Chrysler Corp., arranges a short (15-20 minutes) discussion during dessert on a typical die casting problem. The problem is presented and discussed, and attempts are made to solve it, drawing on the experiences of other die casters and companies.

This is the result of the avid interest displayed at the annual panel discussion concerning common die casting problems, and has made all meetings more valuable and meaningful.

NAME CHANGE

The Hydraulic Press Manufacturing Co., acquired by Koehring Co. in 1956, has changed its name to H-P-M Division, Koehring Co. Previously, this Mt. Gilead (Ohio) manufacturer of plastic molding, die casting, and metal working machines, was known as the Hydraulic Press Manufacturing Co., a Division of Koehring Co.

New Books

TOOL STEEL SIMPLIFIED by FRANK R. PALMER and GEORGE V. LUERSSEN, published by the Carpenter Steel Company, Reading, Pa. 595 pages. Price $2.50 in U.S., $3.00 elsewhere.

Latest developments in the fast changing field of tool steels and their application to tools and dies are described and interpreted in the third and completely revised edition of "Tool Steel Simplified," published by The Carpenter Steel Company.

This volume, first printed in 1937 and revised in 1948, has again been expanded by the original authors, Frank R. Palmer and George V. Luerssen. It is written especially for men who design, make, and heat treat tools and dies.

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CIRCLE 28 READERS SERVICE CARD

PRESSURE DIE CASTING OF STEEL

(Continued from Page 15)

With conventional die casting technique it is extremely difficult to produce complicated steel castings free from internal voids, because of the very narrow ranges within which process variables must be held for satisfactory results, and only non-critical components can be made in this way. Where high density is important, vacuum techniques are recommended. The use of vacuum also offers the possibility of producing castings free from oxide inclusions when die casting steels contain titanium and other easily oxidizable elements.

Shrinkage defects can be largely eliminated by increasing the sizes of runners and gates. Should they then persist in the vicinity of the gates, an increase in the applied injection pressure may be necessary finally to correct the trouble. Plunger speed, however, is the most critical factor affecting the occurance of shrinkage voids. Even if the die is evacuated, voids are formed at high injection velocities. On the other hand, flow lines appear on the surface of the casting when plunger speeds are very low, resulting in a characteristic frosted pattern. Optimum injection velocity must therefore be determined empirically.

Work in this field has supported the assumption that the incidence of voids is correlated with the character of metal flow. With low injection speeds and large runners, flow is smooth and uninterrupted and air escapes from the cavity ahead of the metal. With fast plunger speeds and shallow gates, the metal stream breaks into spray and blocks the vents at an early stage in injection, with the result that residual air and lubricant vapours are trapped. The amount of silicone lubricant applied to the cavity and shot-sleeve should be kept to the minimum necessary to prevent welding.

DIE MATERIALS

SEVERAL die materials were investigated, including low alloy and hot die steels, copper, and copper-based alloys. The usual die steels are completely unsuitable for pressure die casting steel. With such steels, erosion of the die surface becomes evident between the 10th and 20th castings. Materials with better plastic properties, such as Armco iron, low carbon steel, copper, and copper alloys, resist erosion better. Under favorable conditions, some hundreds of castings may be made from dies of these materials.

Pure iron, low carbon steels, and copper, however, have low strength, and deform when the metal is injected under high pressure. They are therefore unsuitable for industrial use. The main problem, at present, in connection with the development of a workable technique for the pressure die casting of steel on a production basis, is to find suitable materials for the dies.

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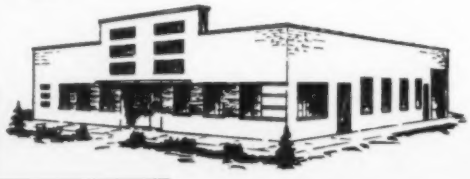

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SDCE NATIONAL BY-LAWS CHANGED

SINCE the Society's Constitution and By-Laws were revised in February 1961, published and distributed to the membership, the Board of Directors has been restudying the dues structure with a view to encouraging new membership and at the same time improving the Society's financial position. The two objectives go hand in hand, for to be strong a technical organization like SDCE cannot ignore the one factor in favor of the other.

It was felt that such action as a general lowering of annual dues, while it might stimulate new membership somewhat, would not yield a net increases in revenues in the foreseeable future. On the other hand, there are special situations, particularly wherein a company has been or might be willing to express an interest in the Society's financial affairs, that warrant action designed to promote new membership.

For some time employees of sustaining companies (those contributing a minimum $150 annual fee) have been invited as new members for the payment of a $12.50 individual annual fee, with the application fee (normally $5.00) waived. To encourage further participation from such employees in SDCS membership the Board of Directors has approved a change in the By-Laws reducing this annual fee to $10.00. In the case of employees of company members (those contributing a minimum $50 annual fee) the application fee for new members has been waived.

It is hoped that this action will make it possible for many more die casting enginers to join on an individual basis, and encourage more die casting and supplying companies to lend their financial support by becoming sustaining or company members.

The changes in Article V of the SDCE By-Laws are dated April 25, 1961, to become effective on invoicings to members after July 1, 1961, as follows:

Change Section 1.A. *from*

"Active Member. Application fee (first year only) $5.00. Annual dues (including first year) $15.00. Exceptions * (1) Individuals employed by Sustaining Member firms, annual dues, $12.50 (Application fee waived)."

to:

"Active Member. Application fee (first year only) $5.00. Annual dues (including first year) $15.00. Exceptions * (1) Individuals employed by Sustaining Member firms, annual dues $10.00 (Application fee waived). (2) Individuals employed by Company Member firms, annual dues $15.00 (Application fee waived)."

Change Section 1.D. *from*

"Company Members. Annual dues $50.00, with the privilege of nominating one (1) individual in the employ of the Company Member as a voting active member, but on a dues-free basis."

to:

"Company Members. Annual dues $50.00, with the privilege of nominating one (1) individual in the employ of the Company Member as a voting active member, but on a dues-free basis. *Note exception in Section 1.A."

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In this particular case not all of the die castings were warped, thus non-uniform cooling had to be the culprit rather than faulty design or ejection. It was found that although the casting itself was water quenched on removal, gate runners and sprue were not. Heat retained by these massive sections reheated and softened the appreciably thinner casting so that internal stresses could warp it.

Since breaking off the sprue immediately upon ejection was impractical, the problem was solved by simultaneously water quenching gate runners, sprue and casting.

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PRESIDENT'S REPORT
(Continued from Page 4)

factory year, which included a substantial boost in operating capital by virtue of earnings from last year's Convention. All Chapters report a better than average year as far as speakers' programs are concerned. The fiscal year has ended at many Chapters with golf outings and wives' nights. These activities have been most successful and have made an important contribution towards cementing relationships between die casters and suppliers.

The new chapter in North Carolina, launched in May, had a very well-attended second meeting in June. It is to the credit of those who organized this new Chapter that it now appears to be on its way to successful operation. Further new Chapters, principally in the West, are planned for the fall. There is nothing significant to report at this stage on the 1962 Die Casting Exposition and Congress, except to state that arrangements are being diligently pursued.

Word has reached us that the Fourth International Pressure Die Casting Conference will be held in May 1963 in Munich, West Germany. It might be wise for those SDCE members who wish to attend with their wives to begin making plans now.

I would like to commend to your attention the statement on a "Code of Ethics" which appears on page 4, and finally, I would like to wish you all a happy and healthy summer vacation.

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People in Die Casting

Bob Black, past Secretary-Treasurer of the Cleveland Chapter, has recently formed the Regent Oil and Chemical Co.

Formerly with a well-known steel company, J. L. Forsyth has accepted the position of general manager of the Industrial Forge and Steel Co. of Canton, Ohio.

Aaron Murphy has joined the Rex-Buckeye Company of Cleveland as general sales manager.

Bud Kozma of the J. A. Kozma Company has recently accepted appointment to the Chapter Liaison Committee of the Society and will assist Dean Rockwell in helping provide greater service to the chapters by the National Office.

Ajax Magnethermic Corporation, Youngstown, Ohio, manufacturers of induction heating and melting equipment, announces the promotion of two executives. Clarence C. Hanson, formerly Vice President in charge of sales, has been elevated to Vice President and General Manager of the Trenton Division, Trenton, New Jersey. James K. McLaughlin moves up from Assistant Division Manager to Vice President in charge of the Youngstown Division.

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